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SOURCE DOCUMENTARY

On file in the CIA Library are copies of the following documents:

(a) Map showing location of electrical installations in Taiwan.

(b) Schedule of electric power development in Taiwan. /In Chinese/

(c) Electric Power Industry in Taiwan, dated October, 1946, prepared by the Taiwan Power Company, Ltd.

(d) Rehabilitation of the Electric Power System of Taiwan, a paper presented to the World Power Conference at The Hague in September, 1947.

(e) A Review of the Electric Power Supply in Taiwan, presented before the 4th meeting of the Taiwan People's Political Council, December, 1947.

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台湾電力公司

臺灣全省電力系統圖

卅六年四月

己成主要發電所一覽表

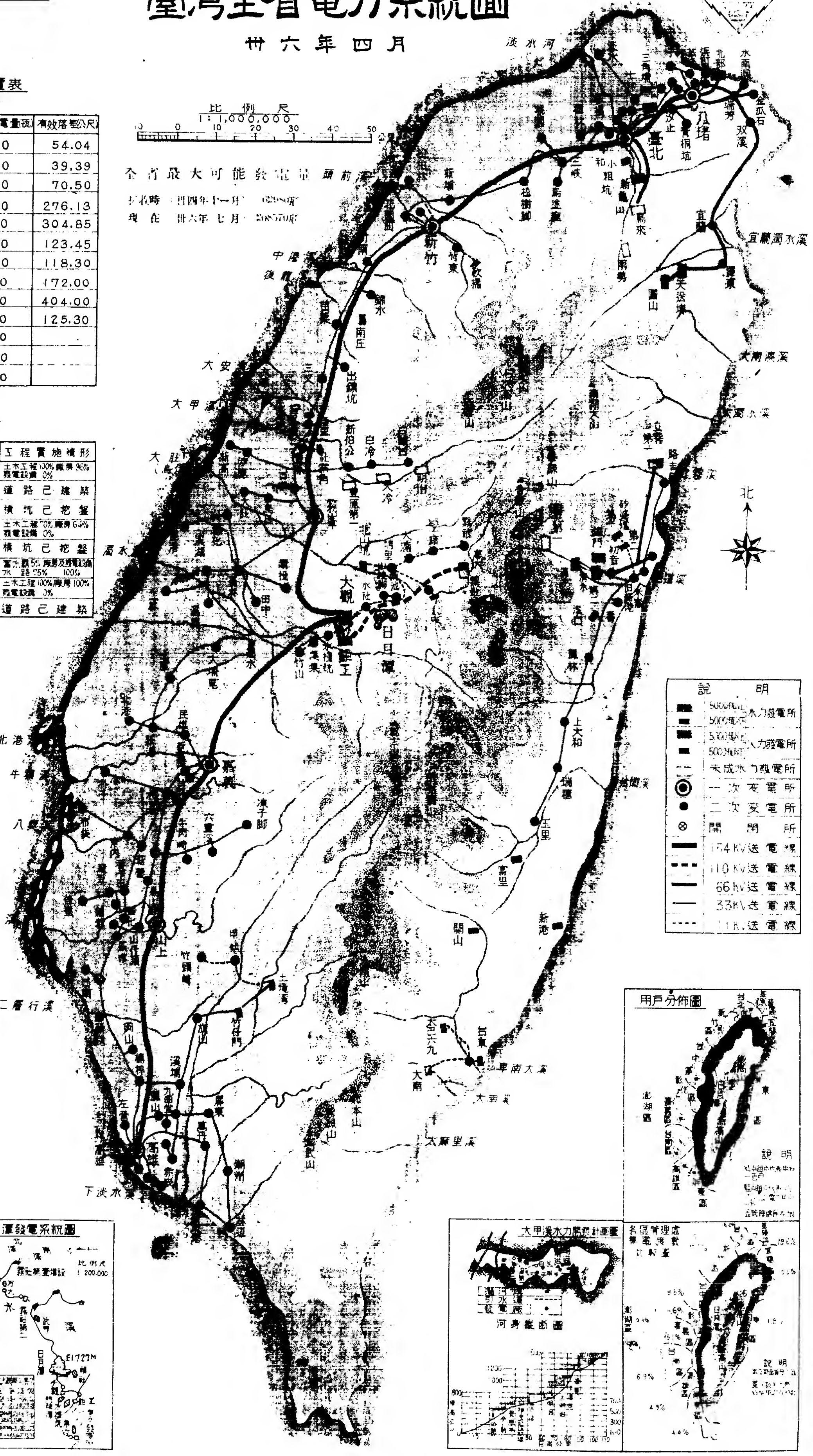
發電量5,000瓩以上

種別	號數	發電所	裝置發電量(瓩)	最大可能發電量(瓩)	有效落差(公尺)
水力	1	新龜山	13,000	13,000	54.04
仝	2	天送埤	8,600	6,500	39,39
仝	3	圓山	16,300	9,000	70.50
仝	4	萬大	15,200	8,000	276.13
仝	5	大觀	100,000	80,000	304.85
仝	6	鉅工	43,500	15,000	123.45
仝	7	立霧第二	15,100	1,000	118.30
仝	8	銅門	24,000	0	172.00
仝	9	清水第一	7,000	7,000	404.00
仝	10	清水第二	5,000	0	125.30
火力	11	北部火力	35,000	30,000	
仝	12	松山火力	5,500	4,000	
仝	13	高雄火力	13,000	10,000	

未成主要發電所一覽表

發電量5,000瓩以上

種別	號數	發電所	計劃裝置發電量(瓩)	有效落差(公尺)	工程實施情形
水力	1	烏來	22,500	91.60	土木工程100% 廠房96% 發電設備 0%
仝	2	南勢	20,000	137.00	道路已建築
仝	3	明治	71,000	173.00	橫坑已挖鑿
仝	4	天冷	71,000	171.00	土木工程70% 廠房64% 發電設備 0%
仝	5	萬源第二	51,200	105.00	橫坑已挖鑿
仝	6	霧社第一	20,000	107.70	蓄水壩5% 廠房及發電設備 水路75% 100%
仝	7	立霧第一	(增設)15,100	118.30	土木工程100% 廠房100% 發電設備 0%
仝	8	溪見第一	12,100	429.30	道路已建築



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1.

A REVIEW OF THE ELECTRIC POWER SUPPLY IN TAIWAN.

Presented before the 4th Meeting of the Taiwan People's Political Council, December 1947.

Two years have now elapsed since Taiwan was taken over by the Chinese Government in November 1945, and this opportunity will be taken to make a brief review based on actual statistical figures to assess the progress of the electric power industry during that period.

2. Maximum Available Generating Capacity.

Movember 1945:	71,380 kw.
Present:	213,355 kw.

The total installed capacity was formerly 321,385 kw, and is substantially the same. Due to frequent floods and typhoons, peculiar to this island the maximum generating capacity available at a time is always below the installed capacity, and in the past it has never exceeded 260,000 kw. Furthermore, the maximum available generating capacity for hydro-electric power systems is based on a plentiful water supply and the comparative figures given above show therefore the work accomplished in the rehabilitation of the power system. To meet the actual power demand, the figure for the maximum available generating capacity will have to be reduced further, depending upon river flow conditions, and normal shutdowns for maintenance repairs.

During the war, the Sun-Moon Lake Hydro-electric Power Plants Nos. 1 and 2 suffered heavy damages through Allied bombings, and ceased operation. At the time of the taking-over, rehabilitation work had not been started, and steam stations could barely supply the demand. However, all efforts were soon directed towards the task of rehabilitation. Spare equipment was put into use, and old and damaged equipment reconditioned. Material difficulties had to be surmounted by hard work and ingenuity. By relying only on our own resources, and without the help of any foreign currency, the available capacity of the Sun-Moon Lake Stations has now been restored to 115,000 kw. If additional transformers can be

obtained, the generating capacity will be raised still further, and the system restored to its original condition. Hydro-electric Stations on the eastern system have suffered heavily through typhoons and floods, and are almost beyond repair. Furthermore, the present load demand there is only about 1,700 kw., and there is ample capacity still available now. Plans are now being made to transfer equipment from there for better utilization on the western system.

As to other generating stations and substations, all have now been rehabilitated. The total available generating capacity has been restored to about 210,000 kw. However, through lack of foreign currency, rehabilitation work that has been carried out up to now, has been done, only by using spare materials and repaired equipment, and cannot be but a temporary measure to meet immediate needs. The system is none too reliable. Industries on the island are being rehabilitated, and the power demand is also steadily increasing. An accident to any one of the main transformers would mean that a whole district or an entire town would be without electric power for many months, and the effect would be disastrous on large sections of the community. It is thus most urgent that adequate protective equipment, repair materials, and spare equipment be ordered abroad to increase the reliability of the whole system, and insure a safe power supply to consumers.

3. Maximum Peak Load

November 1945:	49,678
present:	95,938

Maximum peak load is the maximum power consumed at a time over the whole island, and usually occurs in the evening.

During the war, the maximum peak load ever reached on the western system was about 150,000 kw, and this load was met by combined hydro and steam operation during each yearly low flow period. At the time of the taking-over, the peak load was increased to about 50.000 kw. During the last months of the war the figure dropped to as low as 32,000 kw. At present the peak load is nearly 100.000 kw. Still it is only half of the available generating capacity, indicating that some surplus of electric power supply is still at hand. However lack of maintenance materials, protective equipment and spare parts, as mentioned above has made the situation very delicate.

In fact the load demand should have been higher than indicated above. The insufficiency

of distribution network materials especially of transformers and line conductors, has forced us to turn down new applications for power in many cases. If there had been a sufficient supply of these materials, the load demand would have been surely higher than what it is at present.

4. Electricity Units Sold.

During November 1945:	17,403,740 KWH
This month:	37,440,328 KWH

Electricity units sold at present compared to the time of taking-over has increased by 115%. Increase in lighting and heating has been less and amounts to 39%. Increase in industrial power has been higher and amounts to 188%. Electricity unlike other commodities cannot be stored. Hence power demand can be gauged from the number of units sold and the increase during these last two years is a reliable index of the economic recovery of the island.

5. Energy Used by Industrial Consumers

During November 1945:	11,693,396 KWH
At present:	25,545,567 KWH monthly.

Energy used by industrial consumers is now more than double the figure at the time of taking-over. If energy consumed by the aluminum and magnesium industries is not taken into account, the present consumption is almost equal to the highest figure reached before.

A more detailed analysis of the industrial power consumption shows that consumption of the electro-chemical industries has increased four times compared to the figure at the time of taking-over and is one a half times higher than the highest figure reached before, the increase in the fertilizer industry being the highest. Power consumption by the ceramic industry (including cement) has increased by 100% since the taking-over and is 80% higher than the highest figure reached before. Irrigation and rice milling power consumption has doubled since the taking-over, and is 60% more. than the previous maximum figure. The aluminum factory in Kao-hsiung has just started operation and the power consumption will be greatly increased very soon. Other industries are being quickly rehabilitated. The load demand is thus increasing rapidly and it is safe to predict that in the very near future, industrial power consumption will exceed the previous maximum figure reached during the war years.

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6. Number of Consumers.

November 1945:	395,323 consumers
Present:	409,960 consumers

The number of consumers at the time of the taking-over was below 400,000 and has now increased to 410,000. Compared to the previous maximum figure, it is slightly lower. The main reason for this is that many buildings bombed during the war have not yet been rebuilt. However, the number of power consumers is higher than the previous maximum by about 1,500, most of these being small power consumers. This increase in the number of small power consumers shows a greater diversity and stability and is indeed most encouraging.

7. Electricity Rates

War conditions have brought about an inflation in prices on the mainland, and naturally Taiwan could not escape it. As to electricity rates, adjustment is made only when it is absolutely necessary, and only just above the amount required to cover basic expenses in order to maintain cheap power rates. Electricity rates now compared to prewar rates as follows:

	Flat rate per 40W lamp	Lighting Meter rate per KWH	Power Rate
Prewar rate 1937	¥ 1.00	0.18	About 0.05
Present Rate	¥ 120	18.00	About 10.00
Increase	120 X	100 X	200 X

Besides Taiwan, rates in China are cheapest in Shanghai. Electricity rates in Taiwan were about the same as in Shanghai before the war. Now rates for lighting and heating are four times cheaper here than in Shanghai, and power is seven times cheaper. In fact it can be truly said that electricity rates in Taiwan are the cheapest in China.

Conclusion

Electric power is the basic foundation for industrial development. From the short account given above, it can be readily seen that the power supply and management have been steadily improving during these last two years. From the stage after the war when power supply was insufficient, Taiwan at present is the province of China where electric power is the most adequate, and power rates the cheapest.

Rehabilitation of the various industries has also been making similar progress, and in some cases production is even higher than it had been in the war days. The future economic prosperity of the island will be bound up with its industrialization and electrification, and there is no doubt about its bright future. On the other hand spare equipment, protective equipment and ordinary maintenance materials are lacking with the result that the power supply is now far from being safe. With the pressing danger, our efforts must be directed towards obtaining sufficient foreign exchange to order these necessary materials and attain our goal in providing a safe and reliable power supply.

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臺 灣 之 電 力 事 業

ELECTRIC POWER INDUSTRY IN TAIWAN

臺 灣 電 力 公 司

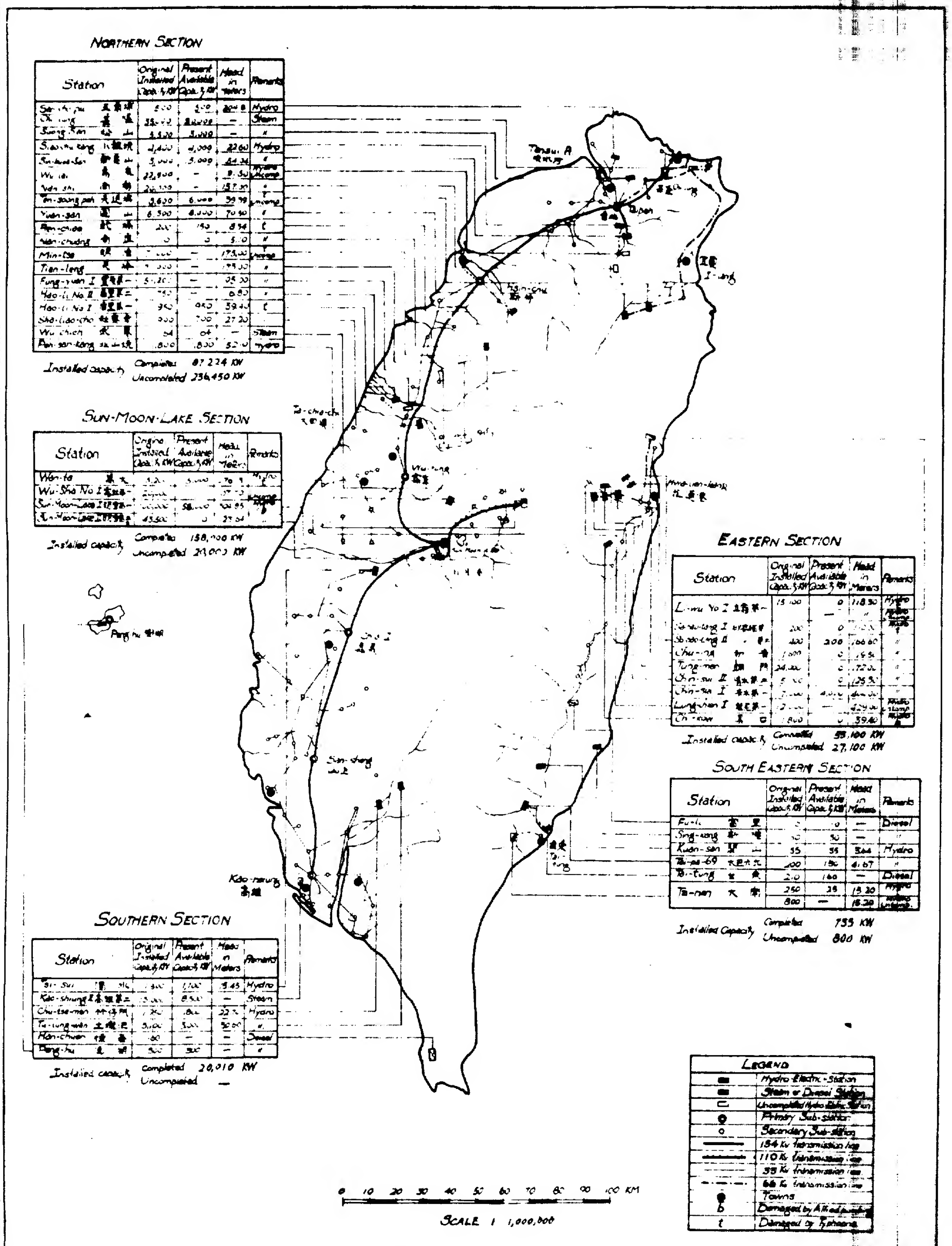
TAIWAN POWER COMPANY, LIMITED

Taipeh, Taiwan, China

October, 1946

台灣電力公司電力系統圖

POWER SYSTEM OF TAIWAN ELECTRIC POWER COMPANY



ELECTRIC POWER INDUSTRY IN TAIWAN

Electricity for illumination purposes was first introduced to Taiwan in 1903, but the Taiwan Electric Power Company came into existence only in 1919. It was formed with the express purpose of developing the Sun Moon Lake (called Jitsugetsutan by the Japanese) hydro-electric plants and in 1944 became the sole supplier of electric power on the whole island. During the war, its activities were extended as far as to Hongkong, South China and the Philippines. After the surrender, the Company was taken over by the Chinese Government in November 1945, and is now operated by the National Resources Commission of China and the Provincial Government of Taiwan.

ELECTRIC POWER AND THE ECONOMIC DEVELOPMENT OF TAIWAN.

Before the war, the colonial policy of Japan aimed at the exploitation of the agricultural products of Taiwan; rice, sugar, tea, fruits, and the consumption of her overproduction of industrial goods, such as fertilizers, textiles, and manufactured articles. During the war, the aluminium, oil refinery, steel, carbide, rubber and alcohol industries were developed mainly to use the island as a base for southward expansion. Now that Taiwan is returned to China, she should supply her own industrial needs by manufacturing fertilizers, making the best use of plants developed for war purposes, encouraging industries, which require raw materials easily obtainable, and which are economically justified, such as sugar, paper, caustic soda, cement, carbide, and expanding her gold, copper, and coal industries.

All these industries, especially the electro-chemical factories, require cheap power for their successful development. Most sugar plants now supply their own power, aggregating to some 100,000 kw by burning bagasse which could be used by the pulp industry. In the past and

during the war years, the industrial development was accelerated by the completion of the Sun-Moon Lake hydro electric stations. The importance of cheap power can thus be easily seen. The potential water power of Taiwan is very large and is estimated at 3,300,000 kw, which is equivalent to about 100 kw per sq km of land area. This figure compares favorably even with those countries of the world richest in water power. However, only one tenth of that power has been developed. Its extensive development is required to meet the cheap power demand which will be even more imperative than in the days of the Japanese exploitation for the reasons outlined above. Ammonium sulphate fertilizer would require 150,000 kw, aluminium and carbide 50,000 kw, other electro chemical industries, sugar, cement, paper, railway-electrification, can all be expanded. A preliminary survey has indicated a demand of 300,000 kw, within three years, and at least 500,000 kw, in the next five years. The task of the Taiwan Electric Power Company will be to fulfill this demand for the orderly economic development of this island.

TAIWAN ELECTRIC POWER SYSTEM.

There are in Taiwan 34 power stations with an original installed capacity of 320,000 kw. Among them 26 are hydro-electric plants amounting to a total of 270,000 kw. The largest ones ~~is~~ are the Sun-Moon Lake Stations No. 1 and No. 2 in the Central part of Taiwan, which altogether give~~s~~ a maximum output of 143,000 kw. Among the 8 heat power stations, the largest one is the Chi-lung steam station, near Chi-lung, with a capacity of 35,000 kw. As determined by the geographical features of the island, the power transmission system is divided into an eastern and a western system to which most power stations are connected. The western system extends from the north to

the south of the island over a distance of 370 km, and power is transmitted at 154,000 v. At seven primary substations the voltage is stepped down to 66,000 v, 33,000 v, or 11,000 v, for the secondary transmission networks. The primary distribution networks are operated at 3,000 v and three phase power is distributed to consumers at 200 v while the lighting voltage is 100 v. The system frepuency is maintained at 60 cycles, which is different from the 50 cycle standard on the mainland. Because of the mountainous nature of the eastern part of Taiwan, it is less thickly populated and industries are not so well developed as in the western part. The eastern system is thus smaller and the highest voltage used is 66,000 v. Work was started to link the eastern and the western systems through the center of Taiwan but was later abandoned. Besides supplying bulk power to the aluminium, calcium carbide, caustic soda, mining and other industries, the distribution system extends to remote rural places and electric power is brought to the modest farmer.

DAMAGES DONE BY ALLIED BOMBINGS AND TYPHOONS.

The electric power supply reached its peak at the beginning of 1944, but subsequently dropped due to a combination of intensified Allied air action and severe typhoon. The first bombing attack on the main power system was made in October, 1944 when three penstocks of the Sun-Moon Lake Power Plant No. 1 were hit. The damage was quickly repaired, and steps taken to make the power station bombproof by adding a meter of concrete to the roof and building a reinforced concrete arch cover over the generating machinery. These preparations were not even ready when Allied bombers came in greater force in March 1945 and, in two waves of bombings spaced ten days apart, both of the outdoor step-up stations at the Sun Moon Lake Stations No. 1 and

No. 2 were accurately hit, and the two stations thus put out of operation. The power station buildings, however, suffered only minor damages with the generating machinery remaining intact. Other bombings on the island caused widespread damages to the distribution sytem and in spite of continuous repairs the power supply diminished rapidly.

Unprecedented typhoon occurred during the summers of 1944 and 1945, and the resulting landslides and floods put most of the stations on the eastern system out of operation. To cite an extreme case, the river bed at the 24,000 kw, Tung men plant was raised by 17 meters and the power house was buried in 10 meters of sand. In addition, many of the stations on the western system were also damaged. Thus through bombings and typhoons, the whole systom was crippled, and at the end of the war, only 40,000 kw could be supplied. This lack of power coupled with the shortage of raw materials caused many industrial plants to be shut down.

PRESENT CONDITION OF THE POWER SYSTEM.

After the transfer of the company to the Chinese Government, rehabilitation work was immediately started. Of the original total installed capacity of 320,000 kw only 40,000 kw were serviceable at the end of the war. By shifting transformers and switching equipment from other substations to the Sun Moon Lake Power Plant, and by repairing damages to other stations due to typhoons, the total available capacity has now been increased to 145,000 kw. The peak load which reached the highest figure of 170,000 kw during the war was only 40,000 kw at the time of the transfer. Repairs to the distribution equipment allowed the resumption of power to industies in general, and the peak load is now about 75,000 kw. In fact, Taiwan is now the only place in China where a large surplus of power is available. The output of

energy for the last six months, from March to August 1946, was almost double that of the corresponding period last year. This gives some indication of the economic recovery of the province as a whole. The number of consumers, including large and small ones, is about 420,000 which means that roughly one out of two households in Taiwan is wired for electric power. The lighting rate is 2 dollars per kwh in Taiwan currency which is equivalent to about 2 cents in US currency and may be considered as the cheapest in the world. Power rate varies from 40 to 80 Taiwan cents per kwh and compares favorably with other places. The number of employees was originally more than 6,000 but with the repatriation of about three quarters of the Japanese last March, the number is now only 4,500. All the remaining Japanese staff with the exception of a few number, will be repatriated before the end of this year.

PLANS FOR FUTURE DEVELOPMENT.

Immediately after the taking over by the Chinese Government, plans were carefully prepared to rehabilitate existing equipment, and to lay down the lines along which development should proceed in the future. Consulting engineers from the J. G. White Engineering Corporation of New York were asked to come to Taiwan to study the problem in its economical as well as in its engineering aspects. After exhaustive investigations, the following program was recommended to be carried out in three steps. The then available capacity of 40,000 kw was to be raised first to 100,000 kw by the partial restoration of the Sun-Moon Lake Power Plant No. 1, and the repair of other smaller stations. This part of the program was completed last February. The second step will increase, by the middle of next year, the available capacity from 100,000 kw to 200,000 kw by completely restoring the

Sun Moon Lake Stations No. 1 and No. 2, and installing one of the two units of the partially completed Wu-lai hydro-electric station.

The third part of the program is scheduled for completion within three years when the available capacity will be increased from 200,000 kw to 300,000 kw. The second unit of the Wu lai station will be installed. Tien leng, one of the eight stations of the Ta chia chi development, and Wu sha hydro-electric station at the center of the island will be completed. Chi lung and Kao-hsiung steam power stations will be extended by 35,000 kw and 20,000 kw respectively to supplement the hydro electric power during the dry winter months, and raise the primary power of the system.

APPENDIX I

THE SUN MOON LAKE HYDRO ELECTRIC POWER STATIONS.

Previous to the development of the power stations, there were two lakes, the Sun lake and the Moon Lake. After the construction of the earth dams to raise the water level. these two lakes were joined into one and are now known as the Sun-Moon Lake. The water of the Tsu-sui river is diverted at Wu chieh by a concrete dam 48.5 meters high, and is led by a tunnel 15 km long to the Sun- Moon Lake. For the purpose of increasing the capacity of the lake, two earth dams were built to raise the water level by 21 meters and the height of the reservoir when full is 2,470 feet above sea level. From this lake, water is drawn off through a pressure tunnel three km long, and is led to the Sun- Moon Lake Power Station No. 1 by five penstocks of a mean diameter of 1.5 meters. Five Pelton water turbines utilize the fall of 320 meters to generate a total capacity of 100,000 kw.

The discharge from the No. 1 Power Station is led by another tunnel 4.3 km long to the regulating pond of Power Plant No. 2. From this pond water is led to the power house by two penstocks, 2.5 meters in diameter with a fall of 123 meters. Power is developed by two vertical Francis turbines delivering 43,000 kw. These two stations are the principal ones of the Sun-moon Lake system. A third one further down the river was planned but no work has been done yet.

Construction work started on the No. 1 Plant in 1919 but was stopped in 1922 due to lack of funds. In 1930 work was resumed and No. 1 station went into operation in 1934. Construction costs amounted to ¥43,956,000. Immediately after No. 1 was completed, work on No. 2 was undertaken, and the station began generating power in 1937. The construction costs for No. 2 station were ¥6,143,000.

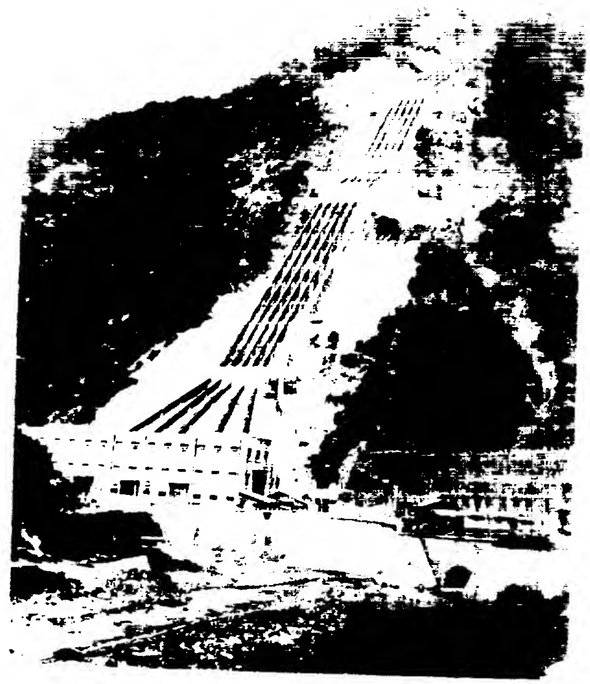
APPENDIX II

TA CHIA CHI HYDRO- ELECTRIC POWER DEVELOPMENT.

In 1942 with the opening of the Pacific War, work was initiated on the Ta- chia- chi scheme to provide 458,000 kw, for the war needs of Japan. That power was to be used to develop the central part of Taiwan with its new Port of Hsinkang, and the water after generating power was also to be used for irrigation purposes. The Ta chia chi drains a large basin in Central Taiwan and is the river with the largest potential power in the island. Ta chien dam was to be built at the head of the river to form a reservoir twice as large as the Sun Moon Lake. The size of the dam would be comparable to the Boulder dam, both in height and in volume of concrete, and its height was fixed at 200 meters, only 18 meters lower than Boulder dam. Below that dam would be a series of eight hydro- electric plants, and work had already been started at three of these sites namely Tien leng, 71,000. kw, Fung- yuan No. 1, 51,900 kw, and Min- tse 71,000 kw. At the end of the war, three quarters of the civil work had been completed at Tien- leng, but no machinery had been installed. At Fung yuan and Min- tse only tunnelling work had been started. Besides exploring the foundations and constructing an access road, no other work had been done on the Ta- chien dam.

Construction on the Ta- chia- chi development was thus the most advanced at Tien leng which is the fifth station of the series and 30 km below the dam site. Work had been started on a previous site, but due to construction difficulties, the tunnel line was changed further south, and work resumed on the present location. Water is led by a 10 km tunnel to a regulating pond and thence to the power station. The available head is 171.5 meters. Prior to the construction of the dam, two vertical Francis turbines will be installed, giving an output of 47,300 kw. After the dam is finished, when the regulated flow will be larger, the number of units will be increased to four with a combined output of 84,500 kw.

Sun-moon Lake



Sun-moon Lake Power Station No. 1

Wu-chieh Spillway Dam

Wu-chieh Intake and Spillway

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臺灣電力系統之修復

REHABILITATION OF THE ELECTRIC POWER SYSTEM OF TAIWAN

Paper Presented to the World Power Conference
at the Hague in September, 1947.

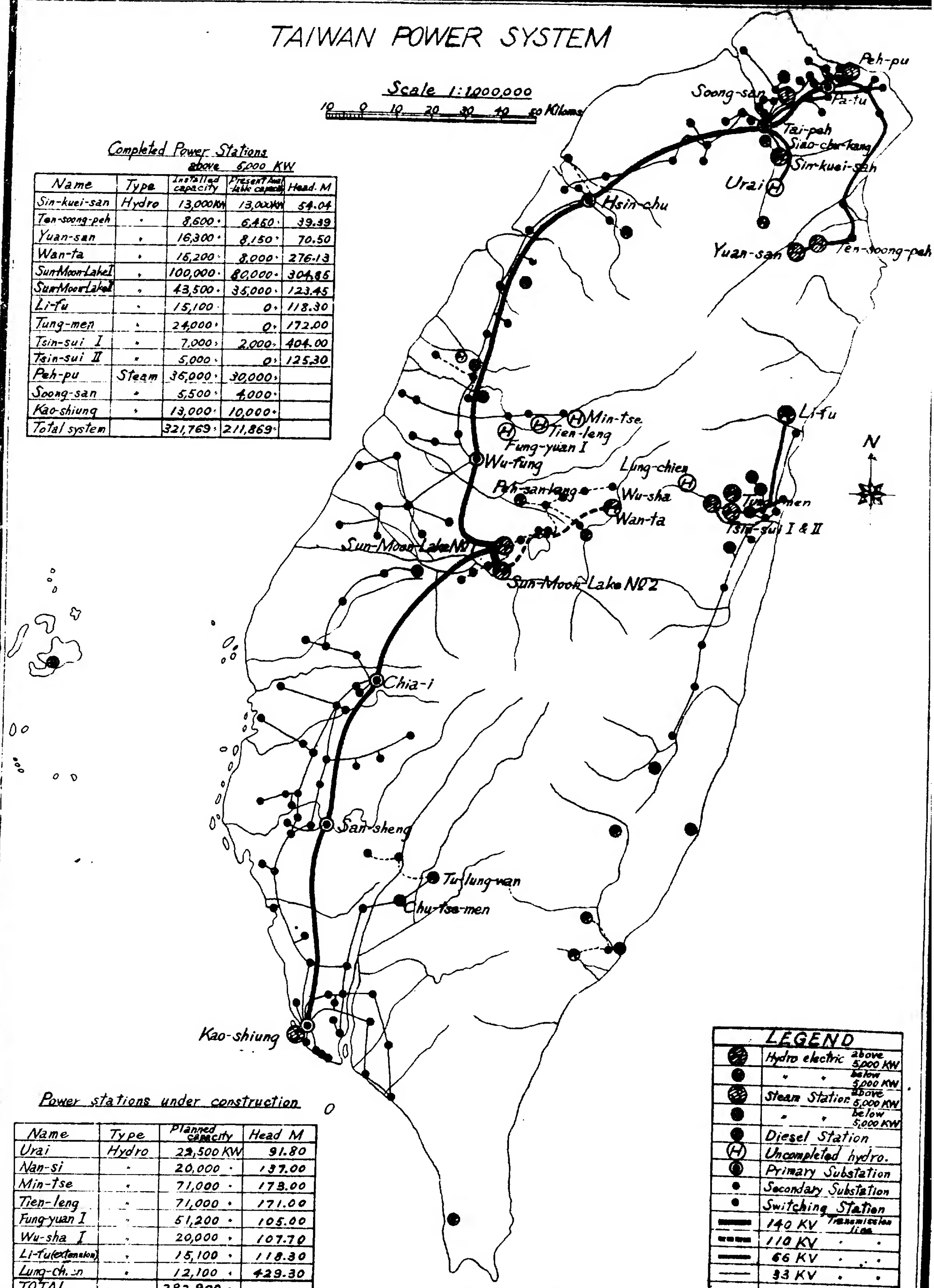
臺 灣 電 力 公 司

TAIWAN POWER COMPANY

Taipei, Taiwan, China

August, 1947.

TAIWAN POWER SYSTEM



Completed Power Stations above 5,000 KW

Name	Type	Installed capacity	Present Available capacity	Head M
Sin-kuei-san	Hydro	13,000KW	13,000KW	54.04
Ten-soong-peh	"	8,600 "	6,450 "	39.39
Yuan-san	"	16,300 "	8,150 "	70.50
Wan-ta	"	15,200 "	8,000 "	276.13
Sun Moon Lake I	"	100,000 "	80,000 "	304.85
Sun Moon Lake II	"	43,500 "	35,000 "	123.45
Li-fu	"	15,100 "	0 "	118.30
Tung-men	"	24,000 "	0 "	172.00
Tsin-sui I	"	7,000 "	2,000 "	404.00
Tsin-sui II	"	5,000 "	0 "	125.30
Peh-pu	Steam	36,000 "	30,000 "	
Soong-san	"	5,500 "	4,000 "	
Kao-shiung	"	13,000 "	10,000 "	
Total system		321,769 "	211,869 "	

Power stations under construction

Name	Type	Planned capacity	Head M
Urai	Hydro	22,500 KW	91.80
Nan-si	"	20,000 "	137.00
Min-tse	"	71,000 "	173.00
Tien-leng	"	71,000 "	171.00
Fung-yuan I	"	51,200 "	105.00
Wu-sha I	"	20,000 "	107.70
Li-fu (extension)	"	15,100 "	118.30
Lung-ch.en	"	12,100 "	429.30
TOTAL		282,900 "	

Fig. 1

REHABILITATION OF THE ELECTRIC POWER SYSTEM OF TAIWAN

THE TAIWAN POWER COMPANY

1. Introduction

After 50 years of Japanese rule, the island of Taiwan (also known as Formosa) was handed back to China after the cessation of hostilities and now constitutes one of her provinces. The island covers an area of about 36,000 sq. km., extending about 360 km. from north to south and about 140 km. from east to west. Its population is about six and a half millions, of which nearly 90% originate from the Province of Fukien across the strait. It is distinctly divided into two parts by high mountain ranges which run all through from north to south with 40 peaks nearly 4,000 meters high. The eastern part is steep and thus comparatively undeveloped. The majority of the inhabitants are distributed over the western part where most of the industries are situated. The main agricultural products are rice, sugar, tea, camphor and fruits. The island is rich in water power resources estimated at some 3,000,000 kw. The war has accelerated the establishment and growth of many industries especially the electro-chemical industries.

The former Japanese Taiwan Denryoku Kaisha which was responsible for the electric power supply to the entire island of Taiwan was taken over by the Chinese Covernment in November 1945. The present Taiwan Power Company was formed soon after and is now operated jointly by the National Resources Commission and the Provincial Government of Taiwan as an autonomous government controlled public service corporation.

2. Original Plants and Equipment

The power system of Taiwan comprises 34 generating stations with an

original installed capacity of 321,885 kw. (Fig. 1). Of these 26 are hydro-electric stations with an installed capacity of about 267,665 kw. and are mostly of the medium head type. Thermal stations are 8 in number with a total installed capacity of about 54,220 kw. Due to the topographical features of the island, power transmission is divided into a western and an eastern system. Construction of an interconnection tie between these systems running across the centre of the island was started but the project had to be abandoned.

The largest of the hydro-electric stations are the Sun-Moon Lake No. 1 and No. 2 stations. Sun-Moon Lake No. 1 (100,000 kw.) was completed in 1934, and utilizes an effective head of 305 m. Sun-Moon Lake No. 2 which is in series with the No. 1 station develops a maximum power of 43,500 kw. at an effective head of 123 m. Power from these two stations is transmitted over a 154 kv. double-circuit transmission line extending along the western section from north to south of the island. There are in all 19 stations on the western system which bring its total installed capacity to 265,870 kw. Included among these stations are three steam stations totalling 53,500 kw.

Main load centres are served by the Patu and Taipeh substations in the north, and the Kaoshiung substation in the south. Principal industries include aluminium, fertilizer, coal, copper and gold mining, electrolytic industries etc., lighting accounting for about 50% of the present total load.

The eastern system comprises 15 stations with an aggregate installed capacity of 56,015 kw. Many of these stations are of small capacity and some are independently operated. The main industry supplied was the aluminium plant in Hualienkang consuming 25,000 kw.

The war accelerated the growth in power demand. Construction work was started on three power stations of the 450,000 kw. Tachiachi project which required the construction of a 200 meter high dam at the head of the Tachiachi River in Central Taiwan and eight Power stations below in series. Only

preliminary work was started on the dam, and by the end of the war none of the power stations of that project had been completed.

The load on the system during the war reached its maximum in 1944 after which intensification of Allied bombings caused a rapid decrease in load and available generating capacity. The maximum peak load ever reached was 176,130 kw. Average load at that time was 148,450 giving a load factor of 84.2%

3. Damages Suffered during the War

Taiwan which served as a Japanese military base was subject to intense aerial bombing as Allied operations approached nearer to Japan. The main targets were of course the Sun-Moon Lake Power Stations which supplied the major portion of the electrical load of the island. Sun-Moon Lake Power Station No. 1 was first bombed in October 1944. Slight damage was done to the penstocks and within one month normal operation was resumed. In March 1945 Allied planes came in force to bomb again the Sun-Moon Lake No. 1 Plant, and one week later the No. 2 Power Plant. At both power stations direct hits were sustained by the step-up transformer substations and the ensuring fires completely wrecked them. The power houses and generating machinery were also damaged to some extent.

Damages were also done to other power stations but they were not so severe. Peipu steam station (35,000 kw.) was one of the other stations bombed. Secondary substations, distribution equipment, buildings etc. suffered extensive damages during the bombings of key cities and towns. Though these were gradually repaired where possible, lack of materials severely restricted their repair during the war, and the ensuing over-loading of the remaining lines caused the burning out of more equipment thus aggravating the situation.

In August 1945, typhoons of unprecedented severity visited the island. Extensive damages were caused to the intakes and waterways of many hydro-stations.

The extreme case was that of the 25,000 kw. Tungmen station of the eastern system where the river bed rose by 17 metres and the generating equipment became completely buried in sand and debris.

In addition to bombing and typhoon damages, poor maintenance through lack of materials and equipment severely curtailed the output of the power stations with the result that at the end of the war only 32,000 kw. could be supplied.

4. Rehabilitation

Soon after the bombing of the Sun-Moon Lake Stations in March 1945, the Japanese started repair work. However, hostilities came to an end in August, and in November 1945 when the Chinese Government took over the island, only one 20,000 kw. transformer had been shifted to the Sun-Moon Lake No. 1 Station. The operating voltage of the main transmission line was a mixture of 154,110 and 33 kv. which made operation most complicated (Fig. 3).

The Japanese staff submitted a plan to restore the system at an estimated cost of U. S. $4,000,000. The J. G. white Engineering Corporation of New York were invited to send engineers to advise on the rehabilitation of the system and submitted a more restricted plan involving the expenditure of U. S. $2,700,000. Both plans called for the purchase of equipment from outside to replace the damaged equipment thus requiring foreign exchange. However the demand for power was most urgent and when it became clear that no foreign exchange was immediately available, it was decided to do the work of rehabilitation by the company's own means. A bold plan prepared by the company and involving the shifting of 200,000 kva. of transformer capacity, oil circuit breakers and associated equipment etc. was conceived and put into operation. The total weight of equipment to be transfered was well over 2,000 tons (Fig 2).

Such a task under normal circumstance would still be a fair size one but the obstacles that had to be surmounted were enormous and lack of personnel was

acute. Of the 6,000 employees of the Power Company more than 3,000 were Japanese, and these filled all the responsible positions. By March 1946 most of the Japanese had been repatriated with the exception of less than a hundred of them. By the end of 1946 only 17 Japanese remained in the service of the company, local trained employees were few and trained personnel from the Chinese mainland was not available in sufficient numbers.

Railways were at that time in a chaotic state, passenger traffic required as much as 36 hours to complete a 300 kilometre journey. Roads and bridges had not been maintained during the war. Of the fleet of 50 trucks belonging to the power company not more than five at a time could be kept on the roads, and these were liable to breakdowns even on short journeys. There was thus no question of shifting equipment as a whole. All transformers were completely dismantled, necessitating the ressembling of the cores, coils, oil tanks, and drying of the insulation under vacuum. Railway facilities were available only to a point four kilometres from the Sun-Moon Lake No. 1 station. From thence heavy equipment had to be skidded along removable wooden sleepers by means of a hand winch, the journey of four kilometres taking from 3 to 5 days. This cumbersome method could be avoided by using tractor equipment but such was not available.

When it became necessary to shift by road a 154/110 kv. 25,000 kva. 3 phase transformer from Wusha to Sun-Moon Lake No. 2 a distance of 48 kilometres, it was broken up into its smallest component parts and yet there were several parts of 8 ton in weight. A steep road which skirted a deep valley with half of the road width supported on wooden stilts, was so unsafe that few people dared to ride over it even in a passenger car. This road had to be completely shored up, and five other bridges strengthened in record time to allow that 25,000 kva. transformer to be brought out before the rains would come and make the roads unusable. Special trailer equipment was built to transport the

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8 ton loads and negotiate one tunnel along that road. From Wusha the road drops down sharply and the sharp hairpin bends were negotiated by tying the trailer with wire ropes and paying them out from a hand winch. These were but difficulties that had to be surmounted in one instance only.

Other phases of the program were time consuming, required a high degree of technical skill, and were often of a dangerous nature. No interruption in the power supply could be tolerated. Rotation of transformers from one place to another had thus to be done in proper time sequence, and also under limitations of space available for the erection of transformers. In a few cases even overhead travelling cranes had to be shifted from one power station to another to allow dismantling and erection of transformers. Drying of the transformers were all done on site and had to be carefully done since they were dismantled to the smallest practicable dimensions to allow easy transportation, and were exposed to frequent tropical rains during transportation.

Damaged structural steel parts of the substation were removed, and new frames added whilst still under 154 kv. operation. Lightning arresters on the 154 kv. system were mostly of the wet electrolytic type. Due to age, frequent thunderstorm discharges, they were no more serviceable, and further no electrolyte was available for refilling them. Experimentation was undertaken to regenerate the oxide films of these cones, and new electrolyte prepared. These experiments proved to be successful, the power factor of the regenerated cones being as good as new ones. Some regenerated units put in operation a year ago are still in good condition today.

One of the most remarkable features in this shuffle of equipment was that no major accident either to personnel or equipment was registered, though it was carried out along side normal operation at 154 kv. A fatal accident to a trained workman, the loss of any single item of equipmant would have been disastrous and the whole program upset or brought to a standstill. In October

1946 when the western system was converted to a single 140 kv. operation, the changeover was completed within ten hours (Fig. 4). On that day many new items of line and transmission equipment were added to the system at the two Sun-Moon Lake Stations and three substations. Tappings were changed at all the other substations. The whole operation amounted to testing the entire equipment at the same time. But due to careful planning and perfect co-ordination, there was not a single mis-operation or failure and no effect was felt by consumers.

After a year and a half of ceaseless and untiring efforts, the program was brought to its successful conclucion within scheduled time in June of this ysar (1947). In September of last year when the work of rehabilitation was just going on smoothly, a severe typhoon cocurred, causing intensive damages. However witbin a very short time, normal operation was resumed and no delay was caused to the rehabilitation program.

The available capacity has now been raised from 32,000 kw. to over 200,000 kw. The continuous hydro-electric power available is 105,000 kw. The peak load is now about 90,000 kw, and the average power about 70,000 kw. so that surplus power is available for the time being. However the load promises to increase sharply very soon with the rehabilitation of industries in general (Fig. 5). The aluminium plant of Kaoshiung which was severely bombed during the war is now being rehabilitated, and is contracting for 20,000 kw. at the end of this year. Thus before long there will be no surplus power, our steam plants being used only for firming up the hydro-electric power output, and are of limited economic advantage due to the high cost and ahortage of coal in the Far East.

5. Conclusion

The first phase of rehabilitation work has now been completed. Although a good deal still remains to be done our first aim to meet the present load demand has been achieved. As the system has been stripped of all its apare equipment

and maintenance was greatly neglected during the war years, the reliability of the system is low. We are now concentrating on the less spectacular though no less important work of improvement in order to bring our system up to modern standards.

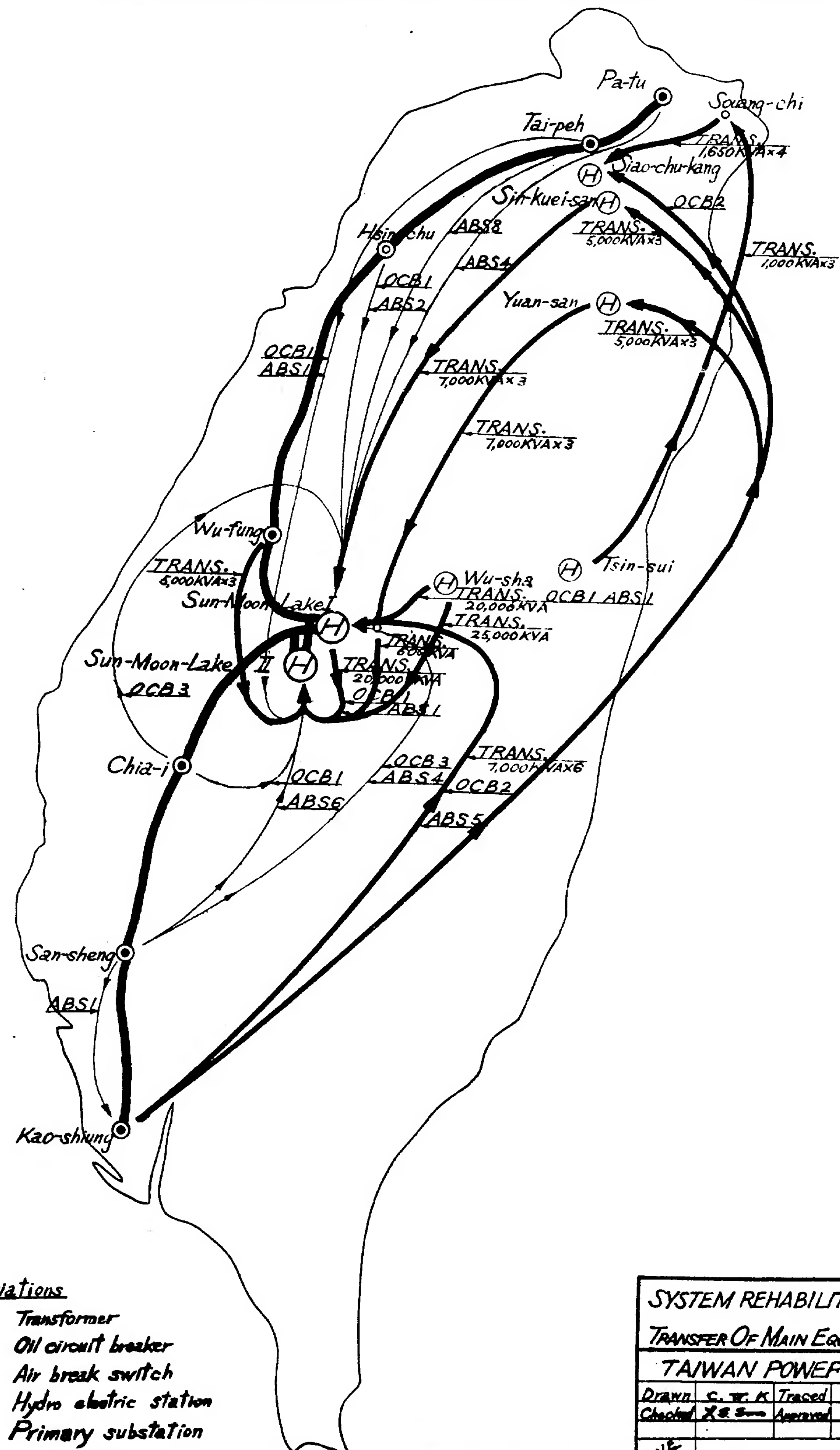
The next work will be the completion of three hydro-electric projects that were left unfinished by the Japanese at the end of the war. They were the Urai 25,000 kw, Tienleng 84,500 kw. and Wusha 20,000 kw.

The Urai project utilizes the flow of one of the best rivers of this island. 90% of the civil work of the Urai project had been completed at the end of the war. The civil work has now been wholly completed. Two vertical Francis turbine units will generate a maximum output of 25,000 kw. at a head of 91. 8 m.

The Tienleng project is one of the eight stations of the 450,000 kw. Tachiachi hydro-electric power development scheme. 70% of the civil work has been completed but no machinery was delivered. The maximum output will be 71,000 kw. before the completien of a 200 m. dam, and will be raised subsequently to 84,500 kw. after the completion of the proposed dam.

Wusha Station is situated above the Sun-Moon Lake Stations. The power house and generating equipment have already been completed. However only 5% of the 98 m. high dam has been completed. The maximum power output at Wusha is 20,000 kw. Besides developing a continuous power of 6,055 kw., the continuous output of the Sun-Moon Lake Stations will be increased by 16,940 kw. due to increase in storage capacity.

Industries on this island have been well developed. Now that the majority of its damaged installations have been restored, by virtue of its wealth of natural resources it will become an important factor in stabilizing Chinese economy. Electric power holds the key to the further development of the island. Given moderate financial and technical help, the potential water resources can be fully utilized and the island built to a high degree of industrialization.



Abbreviations

- **Trans:** Transformer
- **O.C.B:** Oil circuit breaker
- **A.B.S:** Air break switch
- (H) Hydro electric station
- (◎) Primary substation

SYSTEM REHABILITATION			
TRANSFER OF MAIN EQUIPMENT			
TAIWAN POWER CO.			
Drawn	C. W. K	Traced	C. H. L.
Checked	X S Sun	Approved	H. H.
SCALE			

Fig. 2

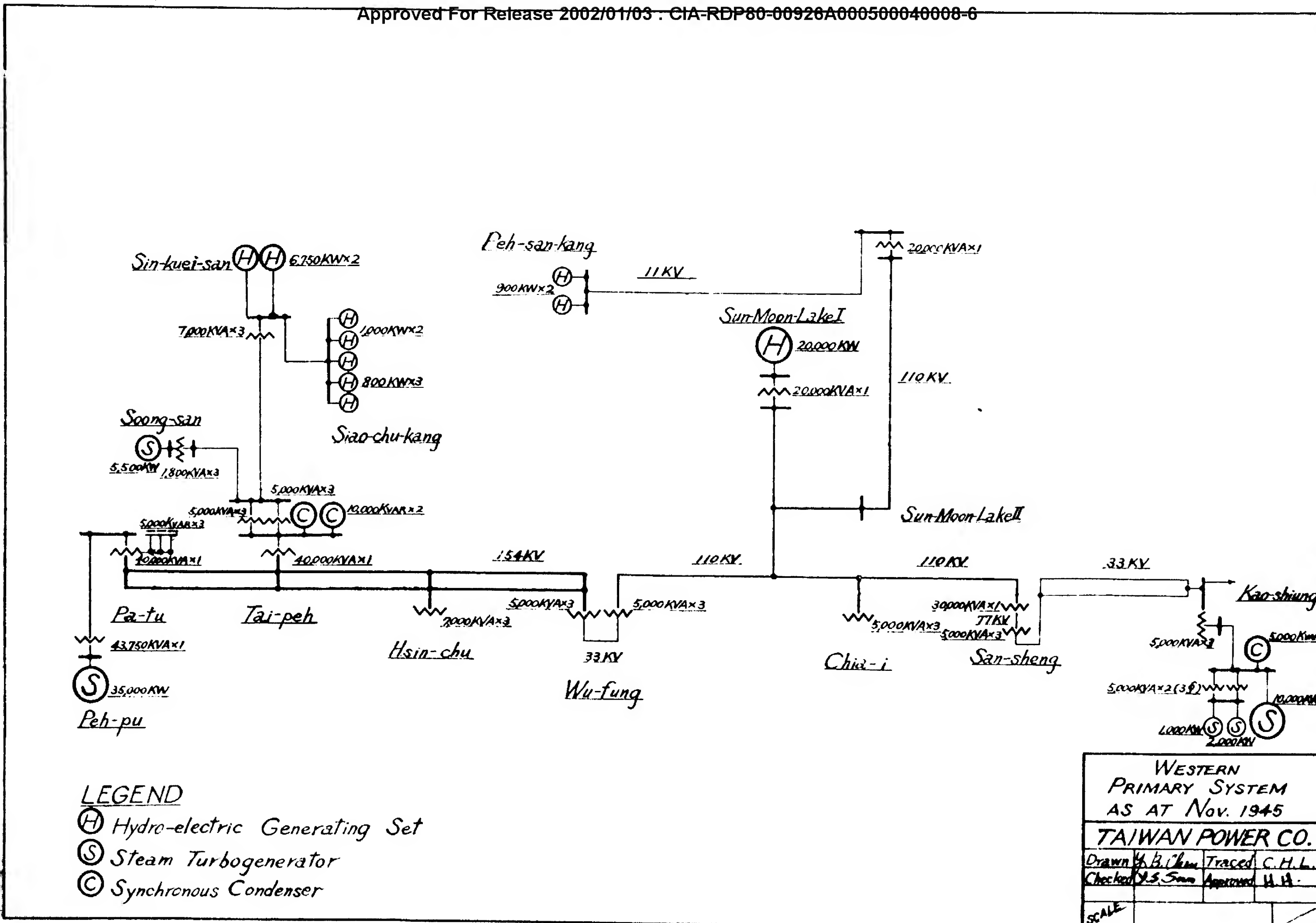

Sin-kuei-san
6,750KW×2
7,000KVA×3
1,000KW×2
800KW×3
Siao-chu-kang
Soong-san
5,500KW
1,800KVA×3
5,000KVA×3
5,000KVA×3
10,000KVAR×2
5,000KVAR×3
20,000KVA×1
40,000KVA×1
Peh-san-kang
900KW×2
11KV
20,000KVA×1
Sun-Moon-Lake I
20,000KW
20,000KVA×1
110KV
Sun-Moon-Lake II
154KV
110KV
110KV
33KV
Kao-shiung
Pa-tu
Tai-peh
2,000KVA×3
5,000KVA×3
5,000KVA×3
Hsin-chu
33KV
Wu-fung
5,000KVA×3
Chia-i
30,000KVA×1
77KV
5,000KVA×3
San-sheng
5,000KVA×3
5,000KW
5,000KVA×2 (3φ)
10,000KW
1,000KW
2,000KW
43,750KVA×1
35,000KW
Peh-pu
LEGEND
Hydro-electric Generating Set
Steam Turbogenerator
Synchronous Condenser
WESTERN PRIMARY SYSTEM AS AT NOV. 1945
TAIWAN POWER CO.
Drawn
Traced C.H.L.
Checked
Approved H.H.
SCALE

Fig. 3

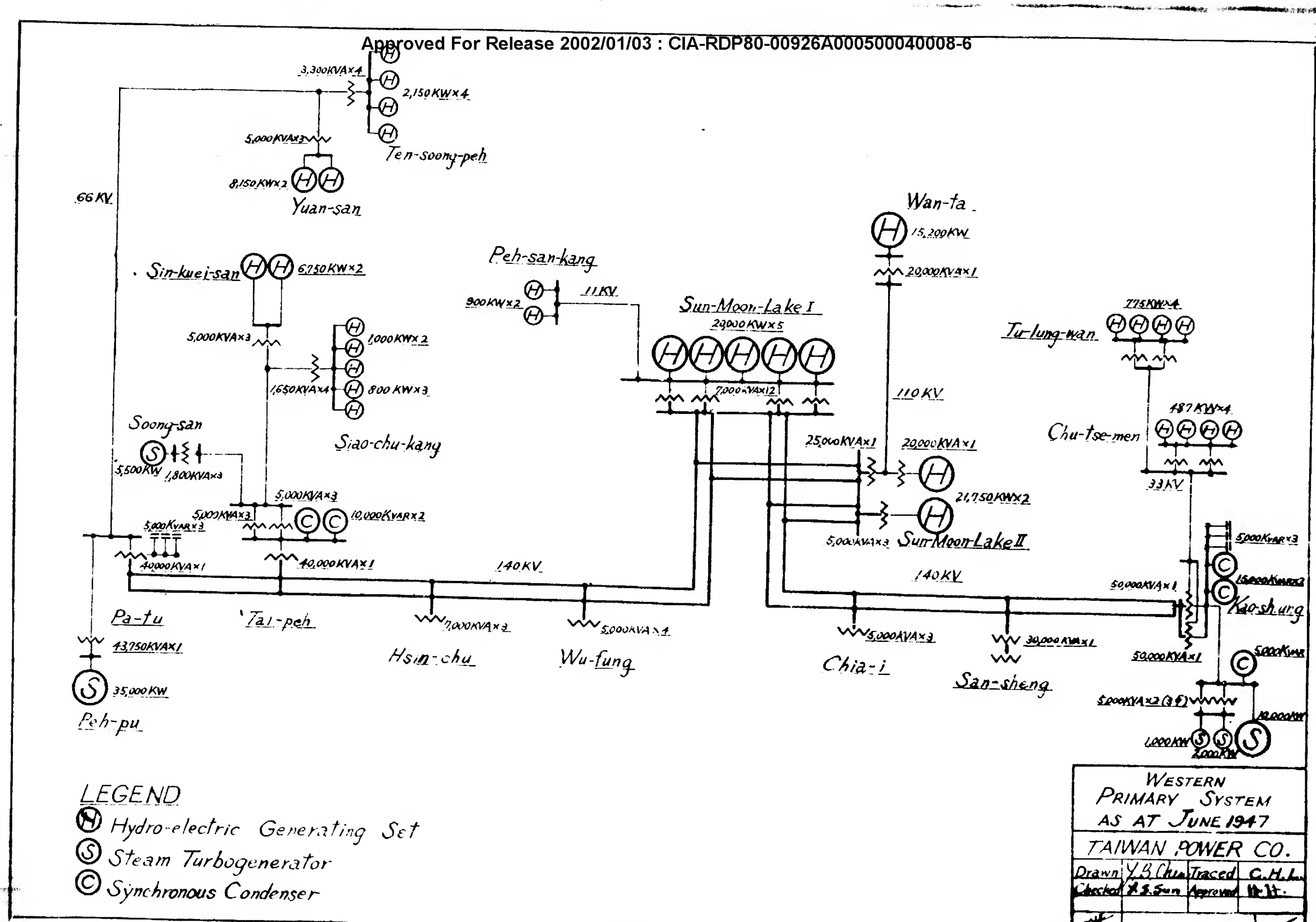
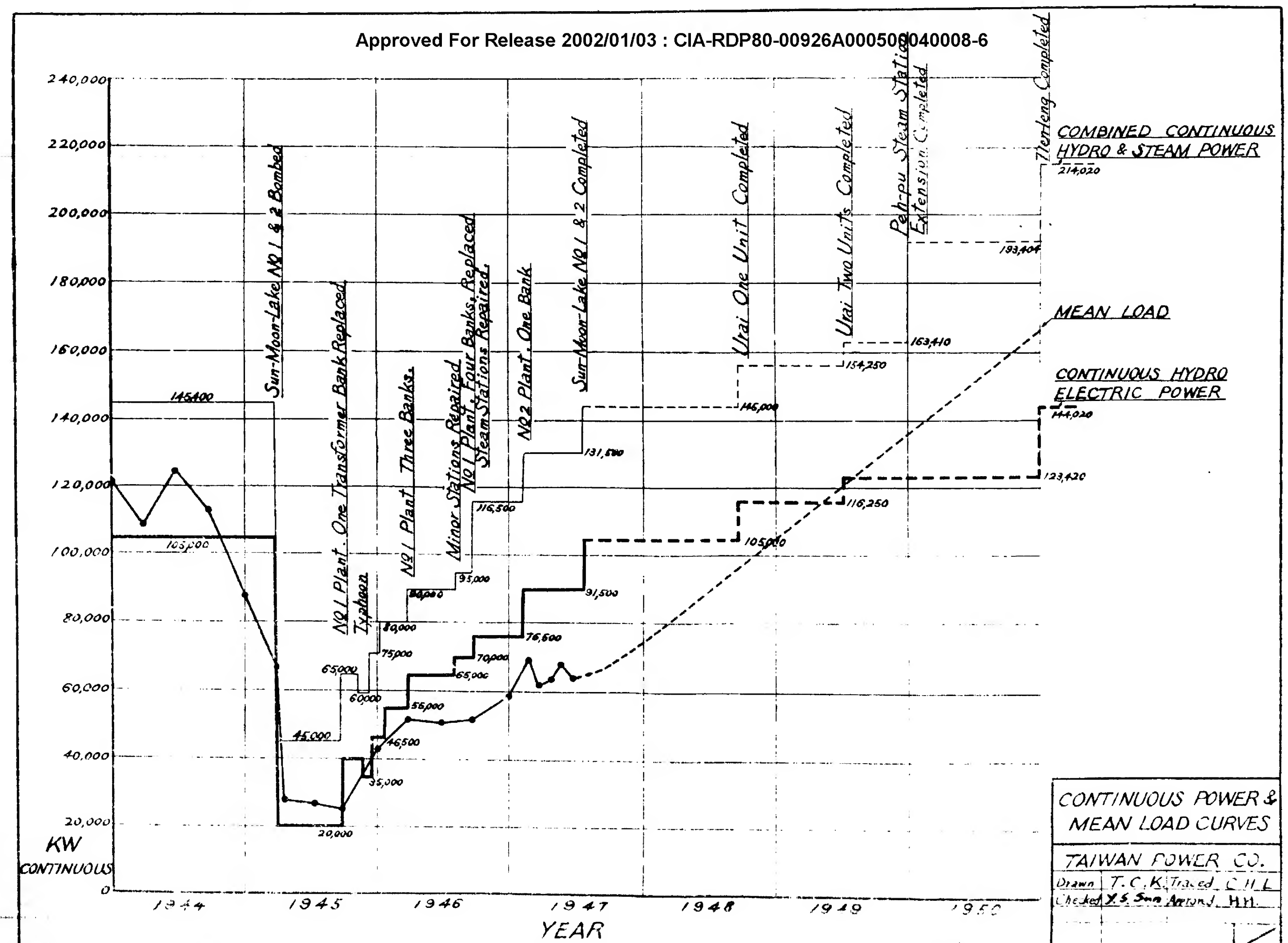

3,300KVA×4
2,150KW×4
Ten-soong-peh
5,000KVA×3
8,150KW×2
Yuan-san
66KV
Wan-ta
15,200KW
20,000KVA×1
Sin-kuei-san
6,750KW×2
Peh-san-kang
900KW×2
11KV
Sun-Moon-Lake I
20,000KW×5
775KW×4
Tu-lung-wan
5,000KVA×3
1,000KW×2
1,650KVA×4
800KW×3
7,000KVA×12
110KV
Soong-san
Siao-chu-kang
487KW×4
Chu-tse-men
5,500KW
1,800KVA×3
25,000KVA×1
20,000KVA×1
5,000KVA×3
5,000KVA×3
10,000KVAR×2
21,750KW×2
33KV
5,000KVAR×3
5,000KVA×3
Sun-Moon-Lake II
5,000KVAR×3
40,000KVA×1
40,000KVA×1
140KV
140KV
50,000KVA×1
Pa-tu
Tai-peh
7,000KVA×3
5,000KVA×4
Kao-shung
43,750KVA×1
5,000KVA×3
30,000KVA×1
50,000KVA×1
Hsin-chu
Wu-fung
Chia-i
San-sheng
35,000KW
Peh-pu
5,000KVA×2 (3φ)
1,000KW
2,000KW
LEGEND
Hydro-electric Generating Set
Steam Turbogenerator
Synchronous Condenser
WESTERN PRIMARY SYSTEM AS AT JUNE 1947
TAIWAN POWER CO.
Drawn Y.B. Chu
Traced C.H.L.
Checked K.S. Sun
Approved

Fig. 4



COMBINED CONTINUOUS HYDRO & STEAM POWER
MEAN LOAD
CONTINUOUS HYDRO ELECTRIC POWER
Sun-Moon-Lake No 1 & 2 Bombed
No 1 Plant. One Transformer Bank Replaced
Typhoon
No 1 Plant. Three Banks.
Minor Stations Repaired
No 1 Plant. Four Banks. Replaced
Steam Stations Repaired.
No 2 Plant. One Bank
Sun-Moon-Lake No 1 & 2 Completed
Urai One Unit Completed
Urai Two Units Completed
Peh-pu Steam Station Extension Completed
Tienleng Completed
145,400
105,000
45,000
65,000
60,000
75,000
80,000
90,000
95,000
116,500
131,500
146,000
154,250
163,410
193,404
214,020
20,000
35,000
46,500
56,000
65,000
70,000
76,500
91,500
105,000
116,250
123,420
144,020
240,000
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
KW CONTINUOUS
1944
1945
1946
1947
1948
1949
1950
YEAR
CONTINUOUS POWER & MEAN LOAD CURVES
TAIWAN POWER CO.
Drawn T.C.K. Traced C.H.L.
Checked Y.S. Sun Approved H.H.

Fig. 5